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APHIS Draft Response to Petitions for the Reclassification of Light Brown Apple Moth [*Epiphyas postvittana* (Walker)] as a Non-Quarantine Pest

Revision 1

Agency Contact:
Plant Epidemiology and Risk Analysis Laboratory
Center for Plant Health Science and Technology
Plant Protection and Quarantine
Animal and Plant Health Inspection Service
United States Department of Agriculture
1730 Varsity Drive, Suite 300
Raleigh, NC 27606

Executive Summary

The U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) has developed this response to petitions submitted on September 12, 2008 and February 4, 2009 to the USDA Secretary of Agriculture, requesting the Light Brown Apple Moth (LBAM), *Epiphyas postvittana* (Walker) be reclassified from an actionable to a non-actionable pest.

APHIS considered the petitions' requests to de-regulate LBAM. To this end, we outlined the key criteria that APHIS uses to determine a pest's regulatory status in accordance with the standard established by the International Plant Protection Convention (IPPC) and the authorities of the USDA. The discussion herein addresses petition elements relevant to our criteria, the nature of invasive species generally, and LBAM specifically.

The petitions also question APHIS' ability to eradicate LBAM; the appropriateness of technologies used to support an eradication program; the potential impacts of these technologies on the environment and to human health and safety; and effectiveness of the communication strategies used to inform the public about the LBAM program. APHIS recognizes the importance of all of these issues; however, for the sake of clarity, we have focused the discussion in this response to the central purpose of the petitions which was to request a change in the regulatory status of LBAM. Questions raised by the petitions regarding regulatory and other actions are distinctly different discussions that will be addressed separately by APHIS via other communications with the petitioners and the public.

APHIS' analysis of LBAM's regulatory status was based on available scientific, expert, and empirical evidence. The study concluded that LBAM is an invasive pest of economic importance because it poses a significant threat to America's agriculture and natural resources. Its findings indicate that LBAM should be classified as a regulated pest because it meets the internationally established criteria for a quarantine pest. Following consideration of public comments received in the Federal Register, APHIS will determine whether to continue Federal enforcement of mandatory phytosanitary regulations and the application of mandatory procedures for the official control of LBAM.

Key findings of the analysis include: 1) significant potential crop production and market losses, ranging from $0.5 to $1.0 billion across 33 States that have a climate and hosts predicted to be suitable for LBAM establishment and survival; 2) potential impacts associated with threatened and endangered species that are hosts as well as negative impacts linked to potential increases in pesticide use; 3) phytosanitary trade barriers and restrictions for US commodities that are hosts of LBAM among U.S. trading partners (as high $9 billion annually); and 4) increased costs due to restrictions on the interstate and intrastate movement of nursery plants.

Next Steps: APHIS acknowledges concerns of the petitioners and has carefully analyzed the factors brought to the attention of the Secretary. A step in the process was that APHIS commissioned the The National Academy of Sciences, National Research Council (NRC) to provide a third-party technical and scientific review of the petition response. APHIS has started to revise its response in accordance with the NRC review. This draft document follows that review and reflects adjustments made by APHIS in response to comments from NRC.

APHIS will make its final decision to the petition request upon reviewing public comments received in response to the posting of this document on the Federal Register. APHIS will continue to consider

the findings of the NRC report to provide additional information in support of the science base of the LBAM program.

I. Background

The first detection in the continental United States of the Light Brown Apple Moth (LBAM), *Epiphyas postvittana* (Walker), was in California (Berkeley area) in 2006 (Brown, 2007), although the specimens collected were not determined to species at the time. Presence of the moth in the State was confirmed in March 2007 (Varela et al., 2008). As of April 22, 2009, the moth had been found in 17 California counties, but its current distribution is limited to 15 counties as a result of current control activities (USDA-CDFA, 2009; NAPIS, 2009b; USDA-APHIS, 2009a). The introduction of LBAM into California has resulted in the imposition of interstate quarantines on several California counties (USDA, 2007), as well as interior California quarantines (CDFA, 2009), restricting the domestic movement of various commodities known to be *E. postvittana* hosts.

The U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) classifies the moth as a quarantine pest that requires phytosanitary measures (designating it as an "actionable pest") when detected in imported commodities. Actions taken to contain or eradicate the pest in response to its introduction constitute an official control program. Such a program is required in order for the United States to take action and prevent LBAM from entering the US when associated with imported products. The implementation of an official control program and maintaining the the regulatory status protects America's farmers who export crops (nursery plants, flowers, fruits and vegetables) from embargoes imposed by trading partners due to concerns that they will harbor LBAM and therefore serve as a pathway for the introduction of LBAM to their countries (see Appendix 1 for an explanation of key regulatory terms). Several States have expressed similar concern regarding the presence of LBAM in California and thus the implementation of an official control program maintains markets.

A petition was submitted on September 12, 2008, to then-Secretary of Agriculture Edward Schafer to formally request the reclassification of LBAM from an actionable to a non-actionable pest. Another petition submitted to Secretary Tom Vilsack on February 4, 2009, includes the same request. Both petitions assert that LBAM is a minor pest similar to other superficial leaf rollers and that "post 2000 data and experience show that LBAM should be handled as a crop quality issue, not as a quarantine pest" (Harder et al., 2008; PANNA, 2009).

Under the Plant Protection Act (7 U.S.C. §7701 *et seq*.), APHIS is charged with protecting the plant resources of the United States against the introduction and spread of harmful exotic plant pests. In this capacity, the Agency is responsible for taking specific actions to exclude, eradicate, or control such pests. APHIS has historically considered LBAM to be a quarantine pest for the United States. LBAM is specifically addressed in Federal import regulations for fruits and vegetables (7 CFR 319.56-13, 2008 and 7 CFR 319.56-20, 2008) and requires quarantine action when detected in imported products.

The criteria used by APHIS to determine the regulatory status of pests are consistent with U.S. obligations under the International Plant Protection Convention (IPPC) (IPPC, 2006). The IPPC defines a quarantine pest as:

- *a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled.* (Article II)

Multiple, independent multi-pest surveys in the United States had not detected LBAM until it was found in California in July 2006 and confirmed in February 2007. LBAM is therefore considered by APHIS to be newly introduced. The current distribution of the pest in the continental United States covers approximately 1% of the area in which it could potentially become established (based on the area proportion of counties infested and predicted to be at risk from Fowler et al., 2009). As an invasive pest of considerable economic importance (e.g., Buchanan, 1977; Bailey et al., 1996; Bailey, 1997; Lo & Murrell, 2000; Sutherst, 2000), LBAM meets the defining criteria for designation as a quarantine pest under the IPPC if maintained under official control in a program designed for containment or eradication (IPPC, 2006. Supplement No. 1 to ISPM No. 5).

This report considers the positions of the petitioners and addresses concerns regarding the basis of APHIS' position on the regulatory status of LBAM as a quarantine pest. The report includes a bibliography of the references cited and also a listing of references consulted by APHIS in preparing this analysis and in the decision-making process that led to regulatory actions for LBAM. This report will be posted in the Federal Register for comment and thereafter, APHIS will review its position on the regulatory status of LBAM.

II. LBAM as an Invasive Species

LBAM is indigenous to Australia, and has long been established in New Zealand, New Caledonia, Hawaii, and the United Kingdom (Whittle, 1984). In Hawaii, LBAM has been reported from a number of locations and hosts at elevations above 1394 ft. since the early 1900s (e.g., 1912 from Lihue, Kauai, on cassia), apparently without causing documented damage to agricultural crops and forest vegetation (Kumashiro, 2007), except on protea "sugarbushes" (Fukada, 2008; see also Zimmerman, 1978).

LBAM's status as an economic pest of fruit crops and managed forest plantation trees is well documented (e.g., Hassan, 1977; Hely et al., 1982; Kay, 1991; Wearing et al., 1991). Thus, as "an alien species whose introduction does or is likely to cause economic or environmental harm …" (Clinton, 1999, p. 6183), the moth clearly fits the definition. Further, LBAM exhibits the qualities of an invasive species in California and in many locations throughout the world. LBAM has shown a tendency to surmount geographical and environmental barriers (e.g., oceans), establish itself, and then expand its population in size and range in new habitats, all hallmarks of invasive species (Ehrlich, 1986; Mack et al., 2000; Richardson et al., 2000). Observations of the species' dynamics in Europe are illustrative. Long restricted to southwestern England (Baker, 1968), in recent times, LBAM has undergone a rapid range expansion in the U.K. (Porter, 2001), and has since been detected in Ireland (Bond, 1998). Recent reports from the U.K. indicate that LBAM populations were causing significant crop damage warranting additional control measures by farmers that specifically targeted LBAM (Fountain & Cross, 2007).

Although natural dispersal of LBAM is limited, with most individual LBAM tending to move no greater than 100 m (Suckling et al., 1994), LBAM has been introduced into new regions by human activity, a pattern shared by most successful invaders (e.g., Baker, 1986; Ehrlich, 1986; Mack et al., 2000; Ruiz et al., 2000; Mack & Lonsdale, 2001; Naylor et al., 2001; Reichard & White, 2001; Fuller, 2003; Kraus, 2003). For example, LBAM is believed to have been introduced into England with apples imported from New Zealand (Carter, 1984). Introduction of the moth into Ireland via passenger ferry from Wales is suspected (Bond, 1998). It is also thought to have been introduced accidentally into New Zealand (Wearing et al., 1991).

Invasion of new regions by LBAM has apparently been associated with LBAM encountering new plant species and cultivars and feeding, reproducing, and in some instances damaging them which has greatly enhanced our understanding of its host range. In Australia, the moth is believed to have originally utilized native evergreens, such as acacias (Clark, 1970). Its present host range has become much broader, and includes a wide variety of cultivated fruit, vegetable, and fodder crops, ornamentals, and broad-leaf weeds (Danthanarayana, 1975). Recent surveys in California have resulted in the addition of new species to its known host list (USDA, 2008a). Similar behavior of insects that in some scenarios were considered relatively innocuous species restricted to insignificant impact in minor hosts have become major pests when introduced to new regions with plant species not previously encountered by the insects (e.g., Tabashnik, 1983; Burke et al., 1986).

The petitions to deregulate the pest, submitted by Harder et al. (2008) and by PANNA (2009) contend that the moth is, at worst, a pest of minor economic significance. However, the evidence regarding its host range, and its apparent capacity to attack a wide range of plant species as its geographic range expands, suggest that LBAM is capable of inflicting considerable economic harm to US farmers.

In assessing the potential of LBAM to impact farms throughout the United States, APHIS used the North Carolina State University (NCSU) -APHIS Plant Pest Forecasting System (NAPPFAST) (Magarey et al. 2007) to model LBAM's potential establishment range as a pest in the United States. NAPPFAST is an internet-based climate mapping system (www.nappfast.org). NAPPFAST has been used to model a large number of exotic pests including plant pathogens (Magarey et al. 2007) and *Scirtothrips dorsalis* (Nietschke et al. 2006). In addition, NAPPFAST has been used to create pest risk maps for the the Top 50 pest targets for national surveillance (www.nappfast.org). NAPPFAST model predictions of potential generation numbers have been validated with reports from the literature for 21 exotic arthropod pests .The North American climate database for NAPPFAST draws from nearly 2,000 weather stations with 30 years of historical daily weather data for each station. The NAPPFAST databases are linked to a generic day-degree template which was used to create the model. After a model has been saved, NAPPFAST can create probability or average history maps based on the most recent 10 years (e.g., 1999 to 2008). Station data are interpolated to a 10 km^2 resolution using a 3-D multivariate linear regression (Splitt and Horrel, 1998).

We used Borchert's (2007) degree-day (DD) model, which was generated using parameters from Danthanarayana (1975), to visualize U.S. areas where LBAM could establish based on climate (Fowler et al., 2009). We considered areas where LBAM could complete at least three generations (≥ 2,221 DD at a base temperature of 7.5°C and maximum temperature of 32°C) to be at risk for establishment based on LBAM's behavior in Australia (Borchert, 2007; CABI, 2006; Danthanarayana, 1975; Wearing et al., 1991). This degree-day model exhibited good validation with regard to predicted LBAM generations in areas where it is known to occur in Australia and other parts of the world (Appendix 2).

The research of Gutierrez et al. (unpublished) was cited by the petitioners. Those research findings suggestedthat areas where the minimum air temperature was ≤ -16°C for at least one day during the year were too cold for LBAM and would prevent its establishment. Although not accepted by a refereed journal, The APHIS study used this information (as a lethal cold temperature) in modeling the potential distribution of LBAM in the United States.To date, information is not available on upper limit temperatures that would impact LBAM survival.

LBAM is known to occur in inland semi-arid irrigation districts in Australia such as Mildura where high summer temperatures are common. High summer temperatures can reduce but do not completely elimate LBAM populations from completing the third and fourth generations (Madge and Stirrat 2001).

We subtracted the lethal cold 10-year frequency of climate suitability output from the three-generation 10-year frequency of climate suitability output. The resulting map estimates areas wherre LBAM could complete three-generations taking into accountnon-lethal cold temperatures (Figure 1). Our analysis indicates that LBAM should survive in a significant portion of the United States where it is capable of becoming a serious pest and threat farm production, horticultural producers and gardners .

Models for predicting the potential distribution of exotic pests can be subdivided into deductive or inductive modeling approaches (Baker, 2002). Deductive approaches have appeal because the information used to develop the forecast is completely independent of observed occurrences of the invasive alien species (Venette et al. 2009). Thus, presence and absence information can be used to rigorously validate the model. Inductive models for exotic species must also deal with extrapolation issues, projecting potential distribution for novel environments well beyond locations used for model development. However, deductive approaches may predict a much broader geographic range than will actually be observed if other limiting factors are ignored or unknown, or if density-dependent factors are significant. Most important, for regulatory decision making, deductive approaches are unlikely to predict a smaller geographic range than will be observed.

The NAPPFAST model is one of a few deductive modeling approaches. Another common modeling tool which was identified in the NRC review is CLIMEX (Sutherst et al. 2007). One limitation of CLIMEX is that it has a large number of parameters which increase the complexity of model development. Trial and error are needed to fit these parameters and it is often not clear as to which parameter needs modification (Baker, 2002). Conversely, the advantage of the NAPPFAST modeling approach is that it has few parameters, each with a clear biological definition. There is a need to validate and compare pest risk models (Venette etal. 2009). Although there have been extensive model comparisons and validations for niche modeling systems for native species, there have been few such studies for exotic pests. A comparison of multiple modeling approaches for *Phytophthora ramorum* found good general agreement between the different modeling systems examined (Magarey, 2005).

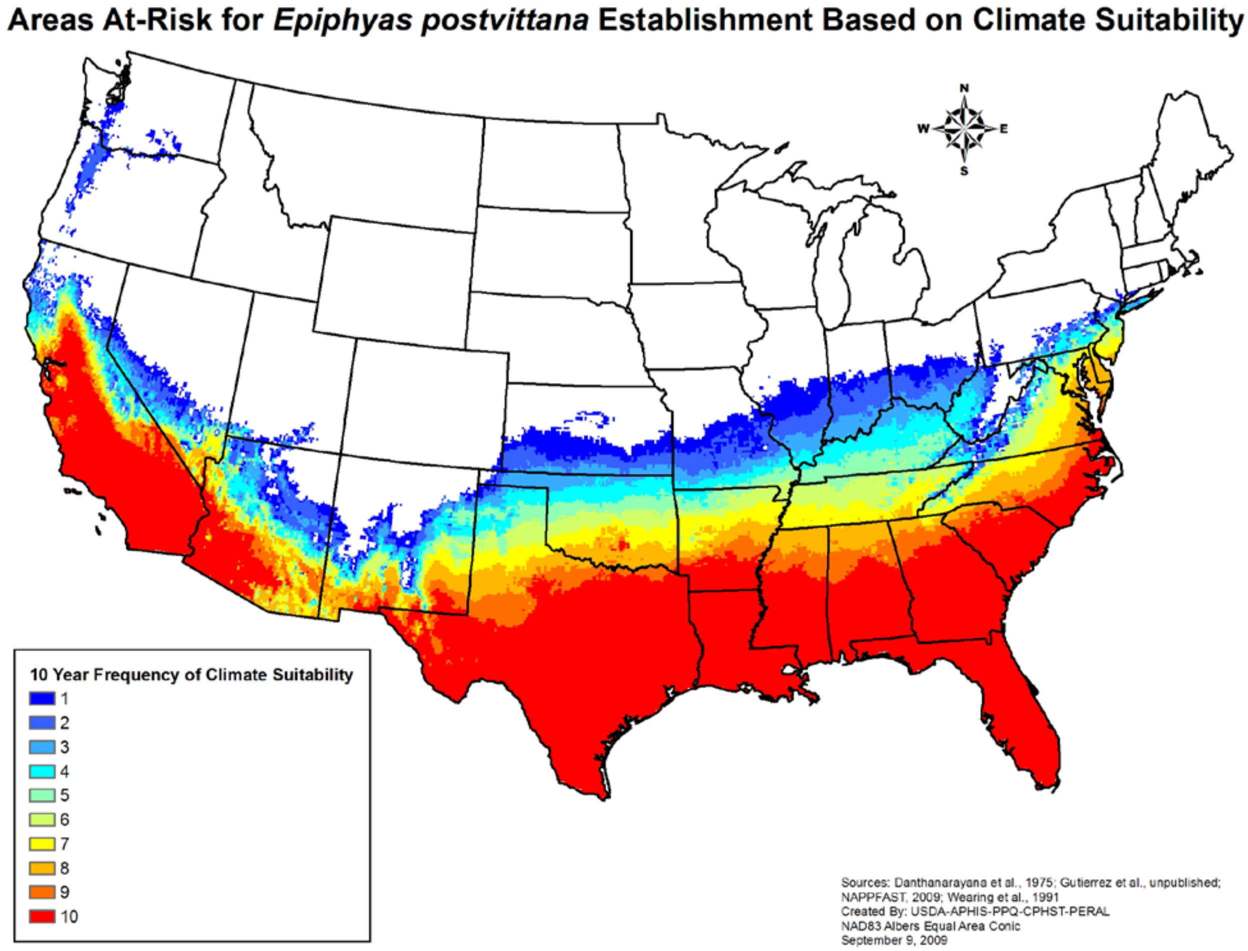

Figure 1. Predicted establishment map for LBAM based on areas in which it could complete ≥ three generations per year and in which non-lethal minimum daily temperatures > -16°C occur.

The petitioners also contend that LBAM should be deregulated because it is not recently introduced to California. They state that “Experts in entomology and invasive species suggest that LBAM has likely been present in California for decades with no notable damage resulting.” APHIS and the California Department of Food and Agriculture (CDFA) have made repeated requests to entomologists in California to provide data in support of this claim over the past year; to date, no data have been provided to substantiate this position. In contrast, APHIS has determined that it is unlikely that LBAM has been present in California for decades given routine surveys at ports of entry and nurseries by the U.S. Department of Homeland Security’s (DHS) Customs and Border Protection branch (CBP) and CDFA to intercept LBAM and to prevent its introduction. Further, results of the Cooperative Agriculture Pest Survey (CAPS) conducted in 2005 indicated that there were no detections of LBAM in the area of California that is presently infested with LBAM (NAPIS, 2009a). Finally, program trapping and routine multi-pest surveys conducted by industry in the currently infested areas were never here-to-fore detected/reported whereas since the initial detection in California average trap catches have steadily increased from 0.1 moth/trap/month in June 2007 to 0.2 moth/trap in April 2008 to 0.4 moth/trap in April 2009 (APHIS, 2009a).

III. Important Economic Factors Considered in the Decision-Making Process to Regulate LBAM

The burden of mitigating the impacts of an invasive pest falls heavily on the exporting region in the form of higher pest management and administrative costs to comply with phytosanitary requirements for commodities in trade (Hoddle et al., 2003). In the United States, APHIS works in conjunction with States to identify and contain invasive species harmful to any segment of the agricultural sector and to natural resources in order to protect the integrity of “at-risk” industries and resources. These measures indirectly protect consumers and producers from unexpected shifts in quality, price, and supply and may also preserve the environment.

LBAM is presently considered a quarantine pest because it does not occur in the United States except in limited areas where it is being contained and targeted with official control. Not all invasive pests are considered to be quarantine pests, and for quarantine pests, not all are considered to be actionable. There are several reasons for this, including in particular the economic importance of the pest, the degree of pest distribution, and the potential for regulatory actions to diminish the impact or slow/stop the spread of the pest. A key reason for classifying LBAM as a reportable/actionable pest is the potential economic impact associated with the detection and spread of the pest to all areas in the United States where it could become established or where it might be introduced seasonally (Figure 1 and Table 1). Without mitigation, LBAM can spread to other regions of the United States from the existing quarantine areas in California.

As for any invasive species, damage or impact on ecosystems is dependent upon a number of variables, e.g. niche breadth, reproductive rate, and competitive ability (Simberloff, 1981, 1989; Vitousek, 1986; Crooks, 2002). LBAM is predicted to have moderate to significant impacts on agricultural, horticultural, and, in certain instances, it may adversely impact naturally occurring host species including threatened or endangered plant species (Fowler et al., 2009). Thus, in addition to agricultural crops, LBAM has a host range that includes trees and ornamental species, giving it the potential to also cause damage to certain ecosystems and to urban and suburban communities. Current regulations for LBAM are designed to curb these potential economic and environmental impacts to agricultural and natural resources by isolating and preventing the spread of the pest beyond the counties currently quarantined. The response programs for LBAM was established to fortify regulations designed to mitigate pest spread associated with interstate and international trade.

The goal of the presentation of economic data and analysis for LBAM is to determine whether the potential costs of the pest are expected to produce economically unacceptable impact. This would include both impacts on domestic values and trade values of commodity hosts. This analysis is not intended to provide exact estimates of the the economic impact of LBAM’s costs, but to provide decision makers with some perspective with regard to the pest’s potential to cause economically unacceptable impacts.

California and Hawaii, along with 32 other states, are major producers of LBAM host commodities. Potential hosts in the existing quarantine area in California and the entire state of Hawaii include nursery products, flowers, foliage, grapes, almonds, strawberries, oranges, tomatoes, lemons, avocadoes, and several others. If LBAM were to be deregulated, the spread of LBAM in California to neighboring counties, and subsequently to other States including Hawaii, would likelyhave broad economic implications for host commodities in terms of trade embargos and higher production costs. The integrity of these industries would be compromised without sufficient regulations to demonstrate to trading partners that regulatory efforts minimize LBAM's impacts.

Table 1. States having counties at risk from light brown apple moth (LBAM).

	Percent of Counties at Risk from LBAM
Western States:	
California, Arizona	100
Washington	44
Oregon	61
Nevada	65
Utah	17
New Mexico	85
Colorado	3
Central & Southern States:	
Texas, Oklahoma, Arkansas, Louisiana, Kentucky, Tennessee, Mississippi, Alabama, Georgia, Florida, South Carolina, North Carolina, Virginia, Delaware	100
Maryland	96
West Virginia	93
Kansas	59
Missouri	64
Ohio	55
Indiana	63
Illinois	62
Eastern States:	
New Jersey	95
Pennsylvania	49
New York	19
Connecticut	25

Source: Fowler et al., 2009 "Economic Analysis: Risk to US Apple, Grape, Orange, and Pear Production from Light Brown Apple Moth, *Epiphyas postvittana* (Walker)", PPQ-CPHST-PERAL, Raleigh, North Carolina. http://www.aphis.usda.gov/plant_health/plant_pest_info/lba_moth/downloads/lbameconomicanalysis.pdf

The current regulatory framework and response program is outlined in the Federal Domestic Quarantine Order DA-2008-17 that was designed to prevent the further spread of LBAM from infested to non-infested areas (USDA, 2008b). The regulations established restrictions on the interstate movement of a list of regulated articles in areas where LBAM infestations are known to exist. As of August 2009, 16 counties in California and all counties in Hawaii are under the Federal Order.

Impacts on Agricultural Production

Geier and Briese (1980) classified LBAM as an “intermediate pest” with respect to its economic status, one that is neither consistently endemic nor characterized by sporadic population irruptions and not generally injurious, but capable of causing damaging infestations in intensive, high-value crops. While the petitioners maintain that LBAM does not cause significant damage under production systems that are not heavily dependent upon insecticide inputs (particularly organophosphates); it is apparent that LBAM has always been a serious pest of various fruit crops in Australia and New Zealand. According to early reports (e.g., Ward, 1931; Fletcher, 1933; Nicholls, 1934; Evans, 1937b; Dumbleton, 1940), LBAM was considered particularly damaging to pome fruit crops in Tasmania. Evans (1936) reported that apple orchards in the state were occasionally “severely attacked.” The moth also severely damaged stored fruit (Evans, 1937a). Its significance as a pest of pome fruit, particularly apple, is said to rank second only to that of the codling moth, *Cydia pomonella* (L.). Damage to fruit in some crops may reach as high as 85% during severe outbreaks (Danthanarayana, 1975). While many of these reports would appear dated, they are highly relevant to the issue at hand and they are highly significant because these losses preceded the use of organophosphates; organophosphates came into popular use in the 1940s (Ware, 1978). The economic impact of the pest in four fruit crops in Australia (apple, pear, grape, and orange), in terms of lost production and control costs, is estimated to exceed A$21 million annually (Sutherst, 2000). In vineyards, a single larva, feeding on developing fruit, can destroy the equivalent of 30 g of mature grapes (Bailey, 1997). The loss and scarring of berries render bunches unsuitable for the fresh fruit market and reduce yields in crops grown for dried fruit; feeding injury to berries contributes to fungal attack, resulting in further loss of yield (Buchanan, 1977). Losses amounting to A$2000 per ha have been reported in some vineyards (Bailey et al., 1996). In Australia, the moth is a defoliator of plantations of *Eucalyptus globulus* Labill. (Collett & McBeath, 2007) which is a tree of value that is used as windbreaks and sight and sound barriers in California (Burns & Honkala, 1990).

Eighty-two percent of the counties in the 33 contiguous States are considered at risk from LBAM establishment and spread based on the reported biology of the pest (Fowler et al., 2009). The Southern Plant Board has requested that APHIS provide federal protection against LBAM The value of sales of potential LBAM hosts among these at-risk states in calendar year 2007 totaled $69.4 billion representing 52% of the reported total value of sales (USCB, 2007). Table 2 provides the crop categories and respective farm operation sales for the at-risk LBAM host commodity groups largely composed of individual LBAM host commodities. As of August 2007, only 25 commodites are listed as being exempt from the conditions required in the LBAM Federal Domestic Quarantine Order for interstate movement of regulated articles (APHIS, 2007a, b). The exemption is applicable only to commodities that are produced using routine production, harvesting, and packaging practices that mitigate the pest. Table 2 provides the crop categories and respective sales for the at-risk LBAM hosts.

Table 2. 2007 U.S. Agricultural Census farm operation sales adjusted by risk for light brown apple moth (LBAM) by commodity groups (billion dollars).

Number of States at risk from LBAM	33 states
Total Counties in States (33 States)	2,376 total counties
Number of Counties at risk from LBAM in 33 States	1,950 LBAM risk counties
Row Crops (Oilseeds, Dried Beans and Peas)	$29.039
Fruit and Tree Nuts	$15.709
Vegetables Fresh Cut Herbs	$11.076
Floriculture, (ornamental plant excluding woody stems, cut flowers, foliage)	$4.371
Nursery stock, (ornamental plants and trees with woody stems)	$5.305
Alfalfa Hay	$3.268
Forest Products, (excluding Christmas trees)	$0.235
Agri-Tourism & Recreational Services	$0.447
Total	$69.449

Source: 2007 U.S. Agricultural Census

This analysis utilizes (Fowler et al., 2009) the high and low ranges for the most likely crop value losses (grapes, apples, pears and oranges) and applies these to the LBAM host crop U.S. Census commodity categories in each LBAM risk area state. The purpose of this effort was to give some perspective of the range of crop values at risk should LBAM expand its range to its ecological limits. For the purposes of this analysis, it was considered unnecessary to address uncertainties as to demand and supply changes and their impact on crop sales losses. As more data are collected from the LBAM quarantine area, a more in-depth economic impact analysis will be needed to determine numerous host commodity price changes and producer costs over multiple crop years.

An initial estimate of the potential economic impact from LBAM was made for all hosts using the most likely high- and low-range proportional crop value loss estimates (Fowler et al, 2009) ranging from 0.023 to 0.010 from the uniform spread and establishment of LBAM in all the States at risk. The resulting national production loss in the LBAM risk areas is estimated to range between $0.694 to $1.597 billion dollars in value annually. California would experience the largest annual production loss among the 33 states ranging between $219 and $503 million in value. California's LBAM risk area alone could be judged as being a minimal justifiable geographic distribution and host range that would represent the lowest range of expected annual economic impact in the near term because of LBAM's existing presence.

California is a leading producer of several singular commodities known to host LBAM. According to Table 3, at least 35 of the top 70 crops produced on California farms are known hosts to LBAM and are of significant economic importance both domestically and internationally (USDA-NASS, 2007). Table 3 reports the leading host crops in California along with their State ranking and value in thousands of dollars. California farms are major producers of the five highest-value fruit and tree nut crops (grapes, almonds, apples, oranges, and strawberries) in the United States.

Grapes are the second-largest commodity in California with a value of more than $3.7 billion in 2006. California grape production accounts for 99% of all grapes produced in the United States. While the largest proportion of California grape production is utilized on the processed market for wine, juice, dried, and canned products, fresh grape utilization does account for roughly 13% of total production (USDA-ERS, 2007). The five leading counties for grape production are Fresno (15.2% of production), Kern (13.3% of production), Napa (12.7% of production), Sonoma (11.6% of production), and Tulare (9.4% of production) (USDA-NASS California Field Office, 2007). Sonoma and Napa counties are currently quarantined due to the presence of LBAM. More notably, Fresno, Kern, and Tulare counties not only represented approximately 80% of all table grape production in 2005 (USDA-ERS, 2007), but also share a border with counties currently under quarantine for LBAM.

Almonds, a potential LBAM host, are the fifth-largest commodity in California with a value of more than $2.5 billion in 2006. The leading counties in the production of almonds are Fresno (19.6% of production), Kern (19.6% of production), Stanislaus (19.6% of production), Merced (19.6% of production), and Madera (19.6% of production). These counties represent three-quarters of almond production and also share a border with counties known to host LBAM.

Strawberries are the seventh-largest commodity in California with a value of more than $1.3 billion in 2006. Monterey, Santa Barbara, and Santa Cruz produced 50.1% of California strawberries in 2006. Ventura and Orange counties are also major producers of strawberries and are located near quarantined counties.

California is also a major producer of fresh oranges. In 2006, total orange production was valued at nearly $1.1 billion in counties that neighbor areas under quarantine (Table 3). Even apple production, valued at nearly $114 million in 2006, can be found in the San Joaquin Valley near counties quarantined for light brown apple moth.

Nursery Products, Flowers, and Foliage

A leading pathway for the spread of LBAM may be through the movement of nursery products and flowers and foliage (Whittle, 1984; Takahashi, 2002). This would include all floriculture and nursery stock plants, including shrubs, trees, and grasses for outdoor and indoor use. Table 4 provides the 2007 floriculture and nursery stock sales adjusted according to those counties at risk for LBAM by State.

Table 3. Reported California state ranking and value of top LBAM host commodities, 2006.

COMMODITY	State Ranking	Value (*$1,000*)
Grapes, All	2	3,706,859
Nursery Products	3	3,095,717
Almonds	5	2,522,886
Lettuce (exempt host, APHIS, 2007 a-b)	6	1,813,261
Strawberries	7	1,340,101
Oranges	8	1,055,666
Hay, Alfalfa	9	1,038,935
Flowers and Foliage	11	792,807
Broccoli (exempt host APHIS, 2007 a-b)	16	545,689
Peaches, All	19	482,042
Tomatoes, Fresh Market (exempt host APHIS, 2007 a-b)	21	428,807
Lemons	23	356,040
Avocados	24	341,492
Celery (exempt host APHIS, 2007 a-b))	25	323,928
Nectarines	27	272,880
Plums, Fresh	28	265,729
Bell Peppers (exempt host APHIS, 2007 a-b)	30	226,598
Cherries	31	221,405
Raspberries	34	188,685
Spinach (exempt host APHIS, 2007 a-b)	35	186,779
Misc Salad Greens (exempt host APHIS, 2007 a-b)	36	183,871
Cauliflower (exempt host APHIS, 2007 a-b)	38	173,251
Cantaloupe	40	162,026
Tangerines	43	124,928
Apples	46	113,933
Pears	48	95,305
Asparagus (exempt host APHIS, 2007 a-b)	49	93,657
Sweet Corn	50	84,779
Artichokes (exempt host APHIS, 2007 a-b)	51	84,661
Cabbage (exempt host APHIS, 2007 a-b)	53	76,601
Beans, Dry	54	75,175
Grapefruit	55	66,825
Apricots	66	34,489
Green Peas	68	24,647
TOTAL VALUE OF HOST CROPS		$ 20,600,454
Total Value Excluding Exempt Host Crops:		$ 16,463,351

Other exempt hosts ((exempt host APHIS, 2007 a-b): Brussel sprouts, Kale, Bok choy, Kohlrabi, Mustard, Collards, Parsley, Squash, Pumpkin, Carrot. Radish, Potato, Beet, Olive, and Walnut .
Source: California Field Office, “Summary of County Agricultural Commissioners’ Reports 2005-2006” (USDA-NASS California Field Office, 2007).

Table 4. 2007 U.S. Agricultural Census sales adjusted by risk for light brown apple moth (LBAM) for floriculture [1] and nursery stock [2] (in billions of dollars).

LBAM risk states	Floriculture	Nursery Stock	Total
California	1.222	1.682	2.904
Florida	0.909	0.844	1.753
Texas	0.326	0.292	0.618
Oregon	0.097	0.507	0.604
North Carolina	0.260	0.252	0.512
New Jersey	0.187	0.176	0.363
Arizona	0.071	0.199	0.270
Tennessee	0.075	0.177	0.252
Washington	0.062	0.103	0.165
Illinois	0.116	0.101	0.217
Virginia	0.115	0.097	0.212
Other States (AL, GA, MD, SC, OH, LA, PA, CT, IN, KY, NY, MS, MO, KS, NM, DL, CO)	0.931	0.875	1.806
Census Disclosure Policy (NV, UT, OK, AR, WV)	No report	No report	No report
Total	4.371	5.305	9.676

[1] Floriculture crops includes ornamental plants without woody stems, including annual and perennial bedding and garden plants, cut flowers, cut cultivated greens, potted flowering plants, indoor foliage plants, and unfinished propagative material.
[2]Nursery stock includes finished ornamental plants and trees with woody stems, including broadleaf evergreens, coniferous evergreens, deciduous shade trees, deciduous flowering trees, deciduous shrubs and other ornamentals, fruit and nut plants intended for outdoor and landscape use, cut and live Christmas trees, and propagation material or lining-out stock. Also includes ornamental vines, and turfgrass sod and other groundcovers. Crops are sold as "balled in burlap," bare root, or container grown.
Source: USDA, National Agricultural Statistics Service, Census Quick Stats, http://151.121.3.59/.

Eleven of the 33 contiguous states that have counties at risk from the establishment and spread of LBAM reported floriculture and nursery stock sales in the 2007 Agricultural Census greater than $200 million. Among these 11 states, Oregon and Florida had the highest portion of their 2007 gross domestic product derived from sales of floriculture and nursery stock, over one-third and nearly one-quarter of one percent, respectively (U.S. Department of Commerce - BEA, 2009).

The production of nursery products is California's third-largest commodity market, valued at nearly $3.1 billion in 2006 (USDA, 2006). Many farms produce nurserystock for interstate/international markets. Flowers and foliage ranked as the eleventh-largest commodity market in the State with a value of nearly $793 million produced by ## farms. The combined 13 quarantined counties, as evidenced in Table 5, represented approximately one-quarter of all nursery stock, cut flowers, and foliage production in the State during 2006. Monterey County produced 8.7% of nursery products in the State making it second only to San Diego County for production of nursery products. Although San Diego produces 51% of flowers and foliage in the State, Santa Barbara and Monterey Counties produce a combined 20.2% and rank second and third, respectively.

Table 5. 2006 Value of nursery, flower, and foliage production in California counties (LBAM quarantined as of June 1, 2009)

COUNTY	Value ($1,000)
Monterey	$339,225
Santa Barbara	178,616
San Mateo	136,021
Santa Clara	94,087
Santa Cruz	80,143
Solano	47,856
San Benito	33,428
Sonoma	27,167
Alameda	20,451
Contra Costa	18,497
Napa	3,557
San Francisco	627
Marin	445
TOTAL	$980,120

Source: USDA, NASS, California Field Office, County Agricultural Commissioners' Data 2006.

Organic Crops
The economic impact of deregulation would be particularly burdensome to producers of organically grown host commodities located within areas known to be infested with LBAM. The cost of alternative treatments for organic farm production would be especially excessive leading to a rise in the price of organic goods that may not compete on market price. Sales of organic host crops grown in California were estimated at more than $420 million in 2005 (University of California, 2007). Table 6 reports the sales of organically grown crops by type and region. While the largest producing areas are located in the Central Coast and the San Joaquin Valley, the South Coast and Sacramento Valley regions are also large producers of organic crops and border most counties quarantined for LBAM. Organically grown hosts of LBAM are potentially at risk of field damage if the pest cannot be controlled with a compound or agent that meets the organic labeling requirement. Based on the climate match analysis, approximately two-thirds of organic products are grown on farms in susceptible counties in California. This translates to an at-risk value of about $276 million (University of California, 2007). Furthermore, the increased use of insecticides targeting LBAM in agricultural settings and urban areas may threaten the integrity of organic production systems and gardens, respectively.

Table 6. California sales of organic crops by type and region, 2005.

Region	Field Crops	Fruit & Nut Crops	Nursery, Greenhouse & Floriculture	Vegetable Crops	Total
			Dollars		
Bay Area [1]	1,268,254	1,564,865	251,136	1,871,361	4,955,616
Cascade-Sierra	5,407,044	1,215,911	7,651	828,413	7,459,019
Central Coast[2]	852,395	30,656,241	3,353,677	114,896,227	149,758,540
North Coast[3]	897,138	16,680,669	971,740	5,307,130	23,856,677
Sacramento Valley[4]	12,453,321	14,820,705	924,572	14,184,721	42,383,319
San Joaquin Valley	2,164,098	62,069,962	448,763	44,412,776	109,095,599
South Coast	1,160,953	27,032,945	372,312	26,751,148	55,317,358
Southeast Interior	346,406	12,770,965	-	12,551,518	25,668,889
Total Sales	**24,549,609**	**166,812,263**	**8,071,675**	**220,803,294**	**420,236,841**

1/ Infested counties in Bay Area - Alameda, Contra Costa, Marin, San Francisco, San Mateo
2/ Infested counties Central Coast - Monterey,San Benito, Santa Clara, Santa Cruz
3/ Infested counties in North Coast - Napa, Sonoma
4/ Infested counties in Sacramento Valley - Solano
" - " Data not reported to protect confidentiality
Source: "Statistical Review of California's Organic Agriculture 2000-2005", Agricultural Issues Center, University of California, May 2007

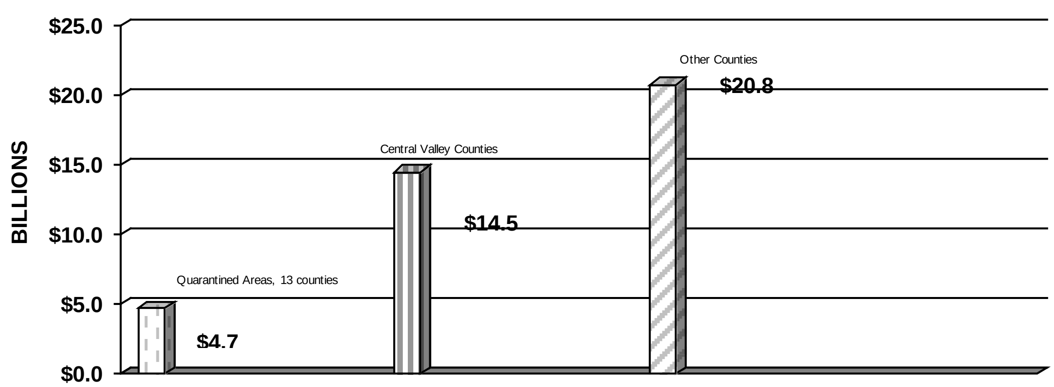

Figure 2. Regional depiction of the value of LBAM host commodities based on 2007 data. (USDA-NASS California Field Office, 2007)

Spread Potential

The spread of LBAM in California from four counties in March 2007 to 12 counties in December 2008 highlights the underlying economic relevance of the current LBAM regulations. The invasive potential of LBAM, illustrated by the history of its range expansion (e.g., Common, 1990; Bond, 1998; Porter, 2001), argues for maintaining its current regulatory status in California. APHIS and CDFA have monitored LBAM populations in California since 2007 and have documented the continual expansion of LBAM within regulated areas and into new areas in California (CDFA website). As illustrated in Figure 2, the current value of production of host commodities in quarantined counties is roughly $4.7 billion. The eventual spread of light brown apple moth to Central Valley counties under deregulation would potentially affect farms that produce LBAM hosts that are valued in excess of $14.5 billion. When all counties in California producing susceptible commodities are included (Imperial, San Diego, Riverside, San Bernardino, Orange, Ventura, and San Luis Obispo) an industry valued at approximately $20.8 billion becomes subject to the adverse economic effects associated with light brown apple moth infestation (USDA-NASS California Field Office, 2007).

Trade

The greatest economic threat posed by LBAM is losses associated with trade restrictions on host plants and commodities in both international and interstate trade.

LBAM is a quarantine pest for several countries that are important trading partners for the United States, including Canada, Chile, Ecuador, India, Japan, Korea, Mexico, Peru, South Africa, Taiwan, and Thailand (Baker, 2005; EPPO, 2007; PRF, 2008). After detection of the moth in California, the government of Canada outlined new regulatory controls restricting the importation into Canada of fresh fruits and vegetables and cut flowers from 13 counties in California (CFIA, 2008). Similar restrictions have been imposed by Mexico, and may be adopted soon by other countries, such as China (Varela et al., 2008).

The 2005-2007 average value of exports of host commodities from at-risk States to countries that regulate for LBAM was $9 billion (Table 7). A data extract was made for each of the three HS chapters for the 33 LBAM at-risk states. This provides the maximum magnitude of export trade value at risk for the three-year period. (US Bureau of the Census: Foreign Trade Division USA Trade Online, 2009). Canada, Mexico, and Chile have LBAM regulations that require specific treatment or additional declarations (AD) for the importation of LBAM host materials.

State plant regulatory officials in 22 of the 50 states and Puerto Rico indicated that they would consider taking state regulatory action if LBAM were reclassified from actionable to non-actionable by USDA. Only 10 state regulatory officials responded that they would take no regulatory action for LBAM should it be deregulated because they are not located in geographic regions where LBAM would become established (APHIS, 2009b).

The majority of the products exported to Canada and Mexico from New Zealand and Australia, where LBAM is endemic, require an import permit to ship. The import permit would have the import requirements (which could include specifications of a treatment and/or Additional Declarations for the pests of concern) for each commodity listed on the permit. A permit would probably be the first new requirement for LBAM host material exported to Canada and Mexico, if California were deregulated for LBAM (Wells, 2009) and would impose additional regulatory requirements on farmers to complete the permit process.

APHIS plans to continue to refine the analysis using trade scenarios as additional data are acquired. This initial analysis provides some perspective as to the range of values among geographically diverse trading partners having phytosanitary concerns for LBAM.

Table 7. Value of exports from LBAM at-risk states of selected commodities by HS-Codes*, to countries that currently regulate for light brown apple moth, avg. 2005-2007.

Country	**HS 06 - Live Trees And Plants**	**HS 07-Vegetables**	**HS 08-Fruits & Nuts**	**Total**	**Percent of Total U.S. Exports From States with LBAM Risk**
	----------------- *Export value ($ billion)*			----------------	
Canada	0.161	1.277	2.016	3.454	74.1%
Mexico	0.026	0.157	0.390	0.573	81.2%
Korean Republic	0.001	0.011	0.211	0.223	96.9%
Thailand	0.000	0.001	0.032	0.033	97.0%
Chile	0.000	0.002	0.011	0.013	86.6%
South Africa	0.000	0.002	0.009	0.011	91.6%
Peru	0.000	0.005	0.000	0.005	55.5%
Ecuador	0.001	0.001	0.007	0.009	100%
India	0.000	0.032	0.188	0.220	94.1%
Japan	0.008	0.121	0.588	0.717	81.8%
Taiwan	0.000	0.033	0.169	0.202	86.3%
Value of U.S. Exports To 11 Countries	0.317	2.085	6.645	9.047	90.5%
U.S. Exports to the World	0.384	2.711	6.894	9.989	
Share of 11 Countries in U.S. World Exports	82%	77%	96%	90%	

Note: the total values for all products under the two-digit HS chapter include the aggregate trade value .

Source: US Bureau of the Census: Foreign Trade Division USA Trade Online. * HS refers to Harmonized Schedule Codes used by U.S. Customs to classify similar imported products for tariff purposes.

Separate analysis of export trade values specific to California for selected LBAM host crops considered in Fowler et al. (2009) is provided in Table 8. These commodities include fresh oranges (HS080510), fresh grapes (HS080610), fresh apples (HS080810), and fresh pears (HS080820). These values are associated with the same 11 partner countries, as shown in Table 7, that have LBAM phytosanitary import trade concerns. The aggregate values of California's export trade for each of the four LBAM at-risk fresh fruits is over half of the entire U.S. export value to the 11 countries. Should LBAM spread or become established in California's agricultural areas, increased risk may prompt trading partners to restrict the flow of LBAM host commodities. Any interruption in trade flows to these export markets is likely to result in negative impact.

Table 8. Value of California LBAM at-risk select fresh fruit exports, to countries that currently regulate for LBAM, avg. 2005-2007.

Country	Fresh Apples HS 080810	Fresh Grapes HS080610	Fresh Oranges HS080510	Fresh Pears HS080820	Total Value
	------------------ *Export value ($ millions)*			----------------	
Canada	8.376	197.922	82.739	8.320	297.357
Mexico	18.603	33.176	4.864	10.044	66.687
Korean Republic	0.029	5.435	81.208	0.000	86.672
Thailand	0.187	10.404	0.172	0.000	10.763
Chile	0.000	0.171	0.110	0.043	0.324
South Africa	0.000	0.012	0.000	0.000	0.012
Peru	0.097	0.031	0.016	0.040	0.184
Ecuador	0.143	2.234	0.114	0.038	2.529
India	1.857	4.824	0.179	0.044	6.904
Japan	0.059	6.103	46.038	0.015	52.215
Taiwan	2.517	20.761	3.633	0.031	26.942
Value of U.S. Exports To 11 Countries	31.688	281.073	219.073	18.575	550.589
Share 11 Country Total of U.S. World Exports	54.32%	54.21%	69.54%	86.28%	

Figure 3 highlights the value of exports to Canada, Mexico, and Chile of specific commodities produced in California that are also susceptible to LBAM. Canada and Mexico are the leading importers of California agricultural products. These two countries also place restrictions on imports of LBAM host commodities. Trade restrictions between these two countries and the United States would likely serve as a guide for other countries producing host commodities. Although exports to Chile from California represent less than 1% of the value depicted in Figure 2, it is important to note that Chile places a strict prohibition on LBAM host articles.

The largest and third largest importers of California table grapes are Canada and Mexico, respectively. Under specified conditions, host articles may enter Canada (B.C.) and Mexico from regulated areas. Grapes from a production site with a positive find are prohibited. These restrictions lead to higher costs for producers, and in cases of positive finds, loss of market access. Considering the magnitude of the value of host commodity export trade from states at risk of LBAM introduction ($9 billion), economic impact may include significant job and business losses, particularly in states that experience high and expansive infestations. Currently, major table grape-producing counties are not infested; however, if LBAM spread to other host crop areas, exports to Canada (B.C.) and Mexico would be prohibited unless post-harvest treatments were applied or the production site met the requirement of International Standard for Phytosanitary Measures No. 10 (IPPC, 2006) for a pest-free place of production, including a buffer zone. The requirement of a buffer zone would be problematic for growers to implement given the horticultural landscape and wide host distribution in the production areas. Additionally, while methyl bromide is approved as a fumigant for surface pests, efficacy data specifically for the light brown apple moth does not currently exist for its application on grapes.

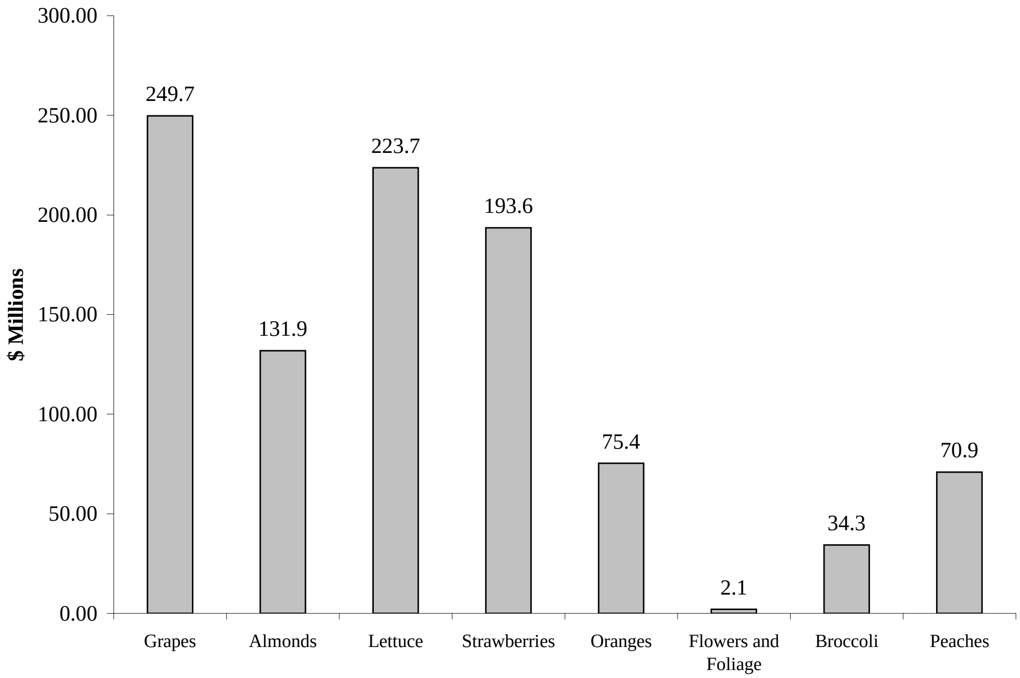

Figure 3. Value of California exports to Canada, Mexico, and Chile, 2007. Source: Global Trade Atlas State Export Data.

Crop Damage

The key reason for instituting quarantine regulations is first and foremost to prevent the crop damage that a new pest could cause in areas previously not known to be affected. Predicting the potential damage of LBAM in the United States is the subject of much controversy. The petitioners have suggested that LBAM is a quarantine pest in New Zealand and Australia primarily because of the restrictions imposed by U.S. import regulations, and because heavy use of organophosphate pesticides in early years was implemented (to comply with the U.S. requirements) which resulted in the elimination of natural enemies that would have limited LBAM damage. The petitions contend that naturally occurring trichogramma or other beneficial insects and organisms in can limit damage caused by LBAM to one percent or less of crops" (petition submitted by Harder et al. (2008)The literature also suggests that natural control can be sporadic, and incapable of preventing economic losses (Nicholls, 1934; Lloyd *et al.*, 1970; Collyer & van Geldermalsen, 1975; Buchanan, 1977). The implication that a pest is considered minor because of a small percentage loss is misleading. For a pest with as broad a host range as the LBAM, the economic losses would be considered significant when damages are summed across the numerous susceptible crops. An assumed proportion of crop damage of 0.010 to 0.023 (Fowler et al., 2009) would mean that American farmers would experience losses that would amount to a $0.694 to $1.597 billion in crop damage losses per year of the major host crops produced in the 33 LBAM at-risk states. This amount is assumed to be a range within the most likely representative lower and upper bounds that would depend on the availability and effectiveness of LBAM's natural enemies to thrive in areas with suitable climate and hosts.

Based on recent experience in Tasmania, the costs of pesticides on a major LBAM host crop such as grapes is anticipated to cost the farmer $7 to $10.50 per acre (2009 US$) excluding application costs (Lo and Murrell, 2000). For example, in the current LBAM quarantine area in California the estimated annual pesticide cost applied to the 2007 agricultural census grape-bearing acreage in the 10 counties would in aggregate range from over $850,000 to $1.275 million. If LBAM were to spread to grape-bearing acreage in all other 33 at-risk states and insecticides were used on 10 percent of the acreage, the pesticide costs could range from over $670,000 to over $1 million annually.

In 2007, APHIS conducted a geospatial analysis of areas at risk in the United States based on climate and hosts (Fowler et al., 2009). The study focused on four major host commodities that included apple, grape, pear, and orange. The result showed that 58% to 100% of the four crops would be at risk for LBAM (apple 58%, grape 97%, orange 100%, pear 73%). Fowler et al. (2009) estimated the mean total annual crop value loss if LBAM were introduced into the at-risk areas to be $104 million. The 5th and 95th percentile values were: $77 million and $132 million, i.e. 95 percent of the time total crop value loss exceeded $76 million. It should be noted that this estimate would likely be much higher were it to consider more hosts. Crop damages could be reduced by pre-harvest treatments but these would add to the cost of production.

Environmental Damage

Silviculture. Of the eight species of Tortricidae causing moderate-to-severe damage to Monterey pine (*Pinus radiata* D. Don) in Australia, LBAM is the most common (Kay, 1991). Neumann & Marks (1976, p. 89) deemed LBAM an important defoliator "sometimes associated with significant damage to seedlings and trees of…conifers" in New South Wales, South Australia, and Victoria. They reported larvae to damage needles and terminal buds of *P. radiata* in nurseries and young plantations. The moth also is among the most important tortricid pests of conifers in New Zealand, and also is found on plantation eucalyptus there (Kay, 1991). In New Zealand, LBAM is found on *P. radiata* and other *Pinus* spp., Douglas fir, and *Picea* spp. (Nuttall, 1983). Larvae use the stems and apical buds of the leading shoots of conifers as winter-feeding and refuge sites. The bud is destroyed and the apical few centimeters of the leader hollowed out; damage results in a malformed stem or multiple leaders (Kay, 1991). On pines, larvae web needles together to form tubular shelters; feeding damages needles, flowers, and green cones (Nuttall, 1983). Brockerhoff et al. (2002) found LBAM to be about as abundant in *Pinus radiata* plantation forests as it was in fruit orchards.

Insecticide Pollution. Buchanan (1977) reported that parasitoids caused about 30% mortality in larvae and pupae of LBAM in both the overwintering and spring generations in Australian vineyards. However, this was insufficient to prevent the pest from causing economic damage. Natural enemies also were reported not to provide satisfactory control of the moth in Tasmanian apple orchards in the absence of insecticidal applications (Lloyd et al., 1970). The petition submitted by Harder et al. (2008) suggested that LBAM infestations, and the damage they cause, resulted from the overuse of insecticides killing off natural enemies, which would tend to keep populations of the pest in check. However, LBAM was known to be a troublesome pest in Australia before the advent of modern synthetic insecticides in horticulture, and capable of causing severe crop losses (Geier & Briese, 1981). Production of high-quality pome fruits is possible only with application of a full schedule of preventive insecticidal sprays (MacQuillan, 1976; Terauds, 1977). Spread of LBAM throughout the United States thus could lead to an increase in the use of insectides to control the pest pm America's farms and residential areas.

Potential Threats to Native Plant Species. As indicated by the number of its disparate host plants, which includes species in numerous families (Whittle, 1984; Brown et al., 2008; USDA, 2008a), LBAM exhibits a wide host range. The moth's introduction into the continental United States puts at risk not only economically important crops and nursery stock, but also populations of native American plant taxa determined by the U.S. Department of the Interior's Fish and Wildlife Service to be in danger of extinction (50 CFR §17.12, 2005). At least 70 of these species, subspecies, or varieties were identified as potential or actual hosts of LBAM (Table 8), based on the moth's known host range. The list includes 26 species, subspecies, or varieties, on which the moth has been recorded since its introduction into California, and which therefore are under increased threat of extinction.

Table 9. Threatened or endangered plant species[1] in the United States potentially at risk of attack by LBAM.

Species	Status	Distribution[2]	LBAM Host Reference
Adiantum vivesii	Endangered	PR	USDA (2008a); Whittle (1984)
Amaranthus pumilus	Threatened	DE, MA, MD, NC, NJ, NY, RI, SC, VA	USDA (2008a); Whittle (1984)
Arctostaphylos confertiflora[3]	Endangered	CA	USDA (2008a)
Arctostaphylos glandulosa ssp. *crassifolia*[3]	Endangered	CA	USDA (2008a)
Arctostaphylos hookeri var. *ravenii*[3]	Endangered	CA	USDA (2008a)
Arctostaphylos morroensis[3]	Threatened	CA	USDA (2008a)
Arctostaphylos myrtifolia[3]	Threatened	CA	USDA (2008a)
Arctostaphylos pallida[3]	Threatened	CA	USDA (2008a)
Baccharis vanessae[3]	Threatened	CA	Brown et al. (2008); USDA (2008a); Whittle (1984)
Berberis nevinii[3]	Endangered	CA	USDA (2008a)
Berberis pinnata ssp. *insularis*	Endangered	CA	USDA (2008a)
Betula uber	Threatened	VA	USDA (2008a)
Ceanothus ferrisae[3]	Endangered	CA	USDA (2008a); Whittle (1984)
Ceanothus ophiochilus[3]	Threatened	CA	USDA (2008a); Whittle (1984)
Ceanothus roderickii[3]	Endangered	CA	USDA (2008a); Whittle (1984)
Cirsium fontinale var. *fontinale*[3]	Endangered	CA	USDA (2008a)
Cirsium fontinale var. *obispoense*[3]	Endangered	CA	USDA (2008a)
Cirsium hydrophilum var. *hydrophilum*[3]	Endangered	CA	USDA (2008a)
Cirsium loncholepis[3]	Endangered	CA	USDA (2008a)
Cirsium pitcher	Threatened	IL, IN, MI, WI	USDA (2008a)
Cirsium vinaceum	Threatened	NM	USDA (2008a)
Clematis morefieldii	Endangered	AL	USDA (2008a); Whittle (1984)
Clematis socialis	Endangered	AL	USDA (2008a); Whittle (1984)
Cucurbita okeechobeensis ssp. *Okeechobeensis*	Endangered	FL	USDA (2008a); Whittle (1984)
Cupressus abramsiana[3]	Endangered	CA	USDA (2008a)
Cupressus goveniana ssp. *goveniana*[3]	Threatened	CA	USDA (2008a)

Eugenia haematocarpa	Endangered	PR	USDA (2008a)
Eugenia woodburyana	Endangered	PR	USDA (2008a)
Euphorbia telephioides	Threatened	FL	USDA (2008a); Whittle (1984)
Helianthus paradoxus	Threatened	NM, TX	USDA (2008a)
Helianthus schweinitzii	Endangered	NC, SC	USDA (2008a)
Hypericum cumulicola	Endangered	FL	USDA (2008a); Whittle (1984)
Ilex cookie	Endangered	PR	USDA (2008a)
Ilex sintenisii	Endangered	PR	USDA (2008a)
Iris lacustris	Threatened	MI, WI	USDA (2008a)
Juglans jamaicensis	Endangered	PR	USDA (2008a); Whittle (1984)
Lilium occidentale[3]	Endangered	CA, OR	USDA (2008a)
Lilium pardalinum ssp. *pitkinense*[3]	Endangered	CA	USDA (2008a)
Lotus dendroideus ssp. *traskiae*	Endangered	CA	USDA (2008a)
Lupinus aridorum	Endangered	FL	USDA (2008a); Whittle (1984)
Lupinus nipomensis[3]	Endangered	CA	USDA (2008a); Whittle (1984)
Lupinus sulphureus ssp. *kincaidii*	Threatened	OR, WA	USDA (2008a); Whittle (1984)
Lupinus tidestromii[3]	Endangered	CA	USDA (2008a); Whittle (1984)
Opuntia treleasei	Endangered	CA	USDA (2008a)
Penstemon haydenii	Endangered	NE	USDA (2008a)
Penstemon penlandii	Endangered	CO	USDA (2008a)
Phlox hirsuta[3]	Endangered	CA	USDA (2008a)
Phlox nivalis ssp. *Texensis*	Endangered	TX	USDA (2008a)
Polygala lewtonii	Endangered	FL	USDA (2008a); Whittle (1984)
Polygala smallii	Endangered	FL	USDA (2008a); Whittle (1984)
Polygonum hickmanii[3]	Endangered	CA	USDA (2008a); Whittle (1984)
Primula maguirei	Threatened	UT	USDA (2008a)
Prunus geniculata	Endangered	FL	Brown et al. (2008); USDA (2008a); Whittle (1984)
Pteris lidgatei	Endangered	PR	USDA (2008a); Whittle (1984)
Quercus hinckleyi	Threatened	TX	USDA (2008a); Whittle (1984)
Ranunculus acriformis var. *Aestivalis*	Endangered	UT	USDA (2008a); Whittle (1984)
Rhododendron chapmanii	Endangered	FL	Meijerman & Ulenberg (2000); USDA (2008a)
Ribes echinellum	Threatened	FL, SC	Brown et al. (2008); USDA (2008a); Whittle (1984)
Senecio franciscanus	Threatened	AZ	USDA (2008a); Whittle (1984)
Senecio layneae	Threatened	CA	USDA (2008a); Whittle (1984)
Solanum drymophilum	Endangered	PR	USDA (2008a); Whittle (1984)
Solidago albopilosa	Threatened	KY	USDA (2008a)
Solidago houghtonii	Threatened	MI	USDA (2008a)
Solidago shortii	Endangered	KY	USDA (2008a)
Solidago spithamaea	Threatened	NC, TN	USDA (2008a)
Spiraea virginiana	Threatened	GA, KY, NC, OH, PA, TN, VA, WV	USDA (2008a)
Trifolium amoenum[3]	Endangered	CA	Brown et al. (2008); USDA (2008a); Whittle (1984)
Trifolium stoloniferum	Endangered	AR, IL, IN, KS, KY, MO, OH, WV	Brown et al. (2008); USDA (2008a); Whittle (1984)
Trifolium trichocalyx[3]	Endangered	CA	Brown et al. (2008); USDA (2008a); Whittle (1984)
Verbena californica[3]	Threatened	CA	USDA (2008a)

[1]Listed in 50 CFR §17.12.

[2]Distribution: AL = Alabama, AR = Arkansas, AZ = Arizona, CA = California, CO = Colorado, DE = Delaware, FL = Florida, GA = Georgia, IL = Illinois, IN = Indiana, KS = Kansas, KY = Kentucky, MA = Massachusetts, MD =

Maryland, MI = Michigan, MO = Missouri, NC = North Carolina, NE = Nebraska, NJ = New Jersey, NM = New Mexico, NY = New York, OH = Ohio, OR = Oregon, PA = Pennsylvania, PR = Puerto Rico, RI = Rhode Island, SC = South Carolina, TN = Tennessee, TX = Texas, UT = Utah, VA = Virginia, WA = Washington, WI = Wisconsin, WV = West Virginia

[3]Listed in USDA (2008a) as a confirmed host.

Additional Costs to Farmers Producing Nursery Stock, Cut Flower, and Foliage

A likely pathway for LBAM to spread from California to uninfested areas is through the nursery trade. This risk is reflected in the import requirements of Canada, Mexico, and Chile for U.S. nursery products, which are more stringent than for fresh fruits and vegetables. Based on one industry estimate, approximately 50% of the volume of nursery products and cut flowers and foliage produced in California are destined for markets outside the State (O'Brien, 2004). Should LBAM be allowed to spread unchecked, the implications for U.S. trade (export and interstate) of nursery products and cut flowers would be additional restrictions ranging from certification for pest freedom, to quarantine treatment, to prohibition.

In order to maintain interstate commerce, nursery stock, cut flowers, and greenery produced in quarantined areas must be inspected and found free of the pest as a condition for movement. The California Nursery Growers Commission/ Nursery Growers Association estimated that the procedures to meet compliance could increase producer costs by $2,250 to $4,570 per acre annually (O'Brien, 2009). These additional costs above current non-LBAM pest management costs are associated with the use of chemical applications, pheromone twist ties, and monitoring of premises.

Due to the impracticality of segregating intrastate and interstate markets, it is likely that all nursery products grown in LBAM quarantine areas would need to be treated in the event that the LBAM were deregulated. According to the 2007 Census of Agriculture, 436,511 acres of nursery and floriculture crops in the 33 LBAM at-risk states were grown in open areas as opposed to under glass or other protection. The nursery and floriculture crops included in this category are vegetable and flower seed crops, and sod harvested, etc. grown in the open. Floriculture crops are defined as bedding/garden plants, cut flowers and cut florist greens, foliage plants, and potted flowering plants. Based upon this estimate, under deregulation the additional cost to producers with open-air production could range between $982 million and $1.9 billion annually.

IV. Summary and Conclusion

APHIS considered arguments articulated in two petitions that requested that the regulatory status of LBAM be changed from an actionable quarantine pest to non-quarantine pest. Findings of the APHIS draft response determined that LBAM is an invasive pest of considerable economic importance which meets the criteria for having Federal enforcement of phytosanitary regulations and the application of mandatory procedures with the objective of eradication or containment as an actionable quarantine pest.

A significant portion of the economic impact is estimated in the form of annual value of U.S. exports (from the 33 states) at risk from phytosanitary restrictions for LBAM among U.S. trading partners (currently at least 11 countries). This cost to America's farmers could be as high as $9 billion based on the pest's maximum potential spread. Furthermore, costs would increase as restrictions are applied to intrastate and interstate movement of nursery products grown in

LBAM risk areas. Maximum pest spread in California accompanied by phytosanitary trade restrictions by major trading partners for U.S. fresh apples, grapes, pears,oranges, and nursery stock could bring up to one-half billion dollars in potential negative economic impact.

The potential crop value losses range annually from $0.694 to $1.597 billion should a significant portion of potential hosts become infested in the pest's projected maximum geographic range covering portions of 33 States (within the contiguous United States). These range estimates are based on the Fowler et al. (2009) proportion of likely loss ranges of 0.023 and 0.01 applied to the aggregate estimated LBAM 2007 commodity safeguarding market value derived from data in the 2007 US Agricultural Census. This does not include impacts on other States that may be subject to seasonal infestations. Under deregulation, the additional cost to producers with open-air production could impact farms in 33 States. This prediction is based on risk analysis of the potential LBAM range and could range between $982 million and $1.9 billion annually.

If LBAM were to be reclassified as a non-actionable pest, APHIS estimates that the lowest range of annual sales losses from LBAM damages would be $694 million (a 1% loss). Under official control, the amount of avoided losses in annual sales compares with the federal funding available in the LBAM emergency response effort of almost $100 million (USDA, 2008c News Release) over a two-year period, indicating a potential, positive benefit-to-cost ratio of at least 6.9 to 1. This does not include potential environmental losses due to factors such as increased pesticide use and other costs associated with widespread establishment of the pest. Additionally, deregulation of LBAM domestically is likely to trigger increased restrictions for LBAM by trading partners, which are expected to have a much greater impact on American farms if LBAM were allowed to spread beyond the current containment area.

V. Literature Cited

[N.B. This section includes all references cited in the document.   A much larger number of references were consulted but not cited above because they were redundant or did not otherwise provide additional information; that more complete list of all articles consulted is presented in the "Literature Consulted"section which follows.]

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VI. Appendices

Appendix 1. Explanation of key regulatory terminology

A *regulated pest* is a pest for which phytosanitary measures are applied under some regulatory authority. *Phytosanitary measures* in this context are regulatory requirements including regulations and programmatic actions designed to prevent the introduction or spread of a pest. When this concept is applied in international trade, a pest is eligible for the application of phytosanitary measures if it meets the defining criteria of the IPPC for a quarantine pest; that is to say that the pest is *of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled*.

Phytosanitary measures are applied by the U.S. and other countries at ports of entry to exclude quarantine pests. When quarantine pests are detected at the border, APHIS may take *quarantine action* depending on the risk associated with the import in question. For example, exotic armored scales found on imported fruit may be technically classified as quarantine pests but action at the border may not be justified because of the very low probability that their movement via this pathway will result in *introduction* (defined as *entry* and *establishment*). On the other hand, the same scales found on imported plants would probably require quarantine action such as a treatment. APHIS further distinguishes pests as *actionable* and *reportable*, where the former requires action when found and the latter is simply noted for tracking and information collection purposes. LBAM has long been considered by APHIS to be an actionable quarantine pest.

In the event quarantine pests such as LBAM are found present inside the U.S., the quarantine action APHIS may take is to establish a *regulated area* and place the pest under *official control* with the objective of either *eradication* or *containment* of the pest. By implementing an official control program, APHIS is able to argue against the application of phytosanitary measures by trading partners who may place restrictions on U.S. exports coming from outside the regulated area. In the absence of an official control program, exports from the entire U.S. are likely to be restricted.

Not all pests fit easily into the categories discussed above. There are a range of situations where the regulatory status of the organism in question cannot be clearly determined. For example, it may not be possible to identify a pest specimen to the taxonomic level required to determine its status, or the organism may have never been encountered previously, or its taxonomy may be changing or under debate. Under such circumstances, APHIS makes a determination regarding whether the organism has the potential to be *quarantine significant*. This only means that the regulatory status of the organism is not solidly established, but the evidence available to APHIS at the time indicates it is reasonable probable that quarantine action would be required.

APHIS generally uses IPPC terminology in its regulations and programs (see ISPM No. 5, Glossary of Phytosanitary Terms (IPPC, 2006)). One reason for this is that APHIS authorities and activities fall within the international framework of the World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement) which identifies the IPPC as the international standard setting organization for phytosanitary measures. Other terminology may be used by other agencies and authorities. Terms associated with invasive species can be particularly confusing in a phytosanitary context because of ambiguities and the overlap of concepts. As a rule, APHIS considers invasiveness to be one aspect of the risk associated with a pest and a key element of risk analysis. As a result, the concept of invasiveness is integral to the concept of pest risk which also includes other factors including the probability and the magnitude of the impact of introduction or spread of a pest.

Appendix 2. LBAM degree day model validation map based on average climatology from 1999 to 2008. Black numbers = generations at validation points and red numbers = generations in countries or country areas, e.g. northern New Zealand.